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Thunderstorm Asthma – Revealing a hidden at-risk population

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ABSTRACT

Background & Aim: To characterise the nature and extent of respiratory symptoms in healthcare workers during the Melbourne Thunderstorm Asthma event.

Methods: A survey was conducted among staff and volunteers across Eastern Health, distributed on the intranet homepage, by e-mail, and by word of mouth. Anonymous survey questions were constructed to assess prior and current diagnoses of relevance, symptoms, and demography.

Results: There were 515 participants (80% female, n=411) who completed the survey of approximately 9000 potential respondents (~6% response rate). 132 (25.6%) had symptoms suggestive of asthma during the ETSA event, the majority of which did not seek professional medical help. Notably, of those with ETSA-like symptoms, only 58 (43.9%) had a history of asthma while 97 (73.5%) had a history of allergic rhinitis. Specifically, a history of allergic rhinitis (OR 2.77, $p < 0.001$), a history of asthma (OR 1.67, $p = 0.037$), and being of self-identified Asian ethnicity (OR 3.24, $p < 0.001$) were all strong predictors of ETSA-like symptoms. Being predominantly indoors was not protective.

Conclusions: Our study provides evidence for the presence of a large cohort of sufferers during the Melbourne Thunderstorm Asthma event of 2016 that did not come to the attention of medical services, implying a potentially hidden and significant susceptible population. Further research should help clarify the true prevalence of vulnerability in the general population, with important public health implications.

Keywords: Asthma, Bronchospasm, Allergic Rhinitis, Thunderstorm, Ethnicity

INTRODUCTION

Epidemic Thunderstorm Asthma (ETSA) refers to an epidemic-level of acute bronchospasm events associated with thunderstorms (1). The mechanism is thought to be due to a confluence of factors including a high burden of aeroallergen, the carriage of these aeroallergens to ground-level by thunderstorms, and the rupture of wet pollen granules by osmotic shock during this process (2-5). These granules release respirable particles which in susceptible individuals may lead to acute bronchospasm. It is important to recognise the importance of the association where usually large granules that are filtered in the upper airways require the elements of a thunderstorm to allow their antigens to reach the lower airway and promote phenotypic asthma (2, 5, 6). Supporting this, it is well known that people with allergic rhinitis are susceptible to ETSA, and occurrences are more frequent during the pollen season (7, 8). Of particular concern is that people without a prior diagnosis of asthma may also be affected (9).

ETSA events have been documented for over 30 years in countries including Australia, the USA, UK, and Iran (10,11). Previously, the largest events witnessed were in 1994 from the UK (with 640 patients with asthma in hospital emergency departments) and in 2013 from Ahvaz, Iran (where 2000 asthma attacks were triggered). This was surpassed by the Melbourne, Australia thunderstorm asthma event on November 21, 2016 that led to 10 deaths and in excess of 3500 patients treated across Melbourne's hospitals – the first thunderstorm asthma event to lead to more than one fatality (12). The rapid and unprecedented development of asthma cases challenged the state-wide emergency response system and brought the phenomenon to the forefront of Australian public health policy, leading to large scale emergency management reforms (11). The epidemic has been a crucial impetus to investigate susceptibility factors and predictors to better inform health management reforms and mitigate the consequences of further potentially catastrophic thunderstorm asthma events (13).

As such, the aim of this study was to characterise the nature, extent, and predictors of respiratory symptoms in healthcare workers during the thunderstorm asthma event of Melbourne, 2016, for the purpose of better understanding those who may be at risk in future events.

METHODS

Study design

We used a cross-sectional study design in the form of an anonymous English language quantitative survey. Participation was voluntary and no compensation or incentives were offered. Consent was implied by participation in the survey. The study was approved by the Eastern Health Human Research Ethics Committee (LR106/2016).

Survey

The internet-based software SurveyMonkey (www.surveymonkey.com) was used as the survey platform. The survey was developed by the research team. Data collected included demographics (including ethnicity and age category), relevant medical history (including recalled history of previous asthma, allergic rhinitis, and allergy), symptoms experienced on the day of November 21 and action/treatment taken (see Appendix for full survey). The survey was distributed to staff and volunteers across Eastern Health, a large tertiary-referral health network in Melbourne, Australia which has over 9,000 employees and volunteers (14). The survey was conducted over a period of 3 weeks between 7 – 28 December 2016. Eligibility criteria included age over 18 years and adequate language proficiency to complete the survey. Participants were recruited from the intranet homepage, email, and by word of mouth.

Statistical analysis

Statistical analysis was performed using Stata/IC 14.1 (StataCorp LP, 2016). No continuous variables were collected. Categorical variables were expressed as frequencies and percentages. Comparisons were made using Fisher's exact test. All predictors of experiencing asthma symptoms identified on univariate analysis with entry criterion $p < 0.1$ were included in a multivariable logistic regression analysis, which included a dichotomised variable for age. A two-sided $p < 0.05$ was used to indicate statistical significance.

RESULTS

Demographics and baseline characteristics

There were 515 participants who completed the survey (see Table 1) of approximately 9000 potential respondents (a response rate of approximately 6%). There were 411 (82.2%) females and 294 (57.1%) participants were under 45 years of age.

A majority (331; 64.3%) had a history of atopy, including allergic rhinitis (262; 50.9%), and atopic dermatitis (71; 13.8%). Additionally, 166 (32.2%) had a history of asthma.

176 (34.2%) participants had a previous diagnosis of allergy to factors including grass (113; 21.9%), dust mite (69; 13.4%), cat (55; 10.7%), food (50; 9.7%), tree (37; 7.2%), weed (29; 5.6%) and mould (24; 4.7%).

Most (416, 80.8%) self-identified as Caucasian. Another 38 (7.4%) identified as Asian, and 27 (5.2%) as Indian / sub-continental.

210 (40.8%) had symptoms of asthma, rhinitis, or both, during the ETSA event. The remaining 305 (59.2%) participants had no symptoms associated with the ETSA event at all.

Prevalence of ETSA

In total, 132 (25.6%) participants experienced at least one ETSA-like symptom, which included shortness of breath (74; 14.4%), cough (66; 12.8%), chest tightness (65; 12.6%) and wheeze (63; 12.2%).

History of Asthma

There were 166 respondents who reported a history of asthma. Interestingly, of the 132 respondents with ETSA-like symptoms, only 58 (43.9%) had a history of asthma. We asked those without a history of asthma whether they had ever had asthma-like symptoms (cough, wheeze, chest tightness and/or

shortness of breath) provoked by rhinitis, exercise, or smells, or if they'd been woken from their sleep by these symptoms. Of the other 74 with ETSA-like symptoms but no reported history of asthma, 52 (70.3%) had at least one symptom suggestive of undiagnosed asthma and 31 (43.1%) had two or more.

History of Allergic Rhinitis

Of the 515 total respondents, 262 (50.9%) reported a history of allergic rhinitis. Of the 132 individuals with ETSA-like symptoms, 97 (73.5%) had a history of allergic rhinitis. Interestingly, 47 of these 97 (48.5%) had no previous history of diagnosed asthma.

Predictors of asthma symptoms

Participants who experienced asthma symptoms during the thunderstorm were more likely to be male, have a history of asthma, allergic rhinitis, or allergy to dust mite, food, grass, tree or weed, and be of Asian ethnicity (including both South and East Asia). Independent predictors for experiencing asthma symptoms (adjusted OR; 95% CI) included Asian ethnicity (3.2; 1.7–6.1), a history of allergic rhinitis (2.8; 1.7–4.7), grass allergy (2.1; 1.1–3.7) and previous history of asthma (1.7; 1.03–2.7) (Table 2).

Outcomes

Of the 132 participants who experienced asthma symptoms, the majority (80; 60.6%) took their usual treatment. Only 10 (7.6%) participants sought medical attention, including nine who attended their general practitioner and one who presented to a hospital emergency department. Forty-two (31.8%) participants with symptoms took no medical action. Treatments used by those who experienced asthma symptoms included bronchodilator inhalers (67; 50.8%), anti-histamines (56; 42.4%) and oral corticosteroids (12; 9.1%).

DISCUSSION

Principal findings

This study shows that ETSA-like symptoms were prevalent amongst health network staff and volunteers who responded to the survey, with one in four respondents developing symptoms during the Melbourne thunderstorm event of 2016. However, the majority of people who experienced symptoms did not seek professional medical help, suggesting that current data which focuses on emergency department presentations may underestimate the size of the population at risk of thunderstorm-related asthma events.

This study supports well-documented evidence that suggests a history of allergic rhinitis or grass pollen allergy increases the risk of developing thunderstorm asthma (2, 7, 15). As expected, the Melbourne thunderstorm asthma event occurred during the pollen season of Australia and coincided with peak atmospheric grass pollen concentrations which typically occur toward the end of November in Melbourne (4). However, the rates of allergic rhinitis being reported in our study are below those published in other studies. Two recent papers (16,17) have reported higher prevalence of allergic rhinitis in ETSA between 90 and 99%, compared with our finding of 73%. This difference may be the result of methodological variance (ours being a web-survey with less nuance than a face-to-face consultation as in the other reports) or may instead reflect the lower prevalence of our lower severity group.

A history of asthma doubled the risk of developing ETSA-like symptoms in our group. This is unsurprising as environmental allergens are a common trigger for acute bronchospasm (15, 18). Approximately one third of respondents with a history of asthma developed symptoms during the event, and it is likely that these individuals have airway hyperreactivity to pollen allergens, while the remaining two thirds have other asthma triggers. To our knowledge, there have been no studies investigating the relative frequencies of triggers in individuals with asthma in Australia.

Prior to the 2016 ETSA event, there had been no studies identifying that having Asian ancestry independently triples the risk of developing thunderstorm asthma. Approximately 12.9% of all Australians are ethnically Asian, with the majority living in large cities such as Melbourne and Sydney (17). In 2016, approximately 20% of people living in Melbourne were of Asian descent (19). Asian Australians are known to have a higher prevalence of atopy (20), and in our study a history of allergic

rhinitis or asthma confers greater risk of thunderstorm asthma. It is therefore interesting that Asian ethnicity is an independent risk factor despite adjustment for history of allergic rhinitis, asthma and other relevant grass/pollen allergies. Previous studies have shown that there may be environmental and geographical factors as length of residency of Asian immigrants in Australia is associated with higher risk of developing asthma (20). It would therefore not be surprising if environmental factors similarly played a role in an increased risk of thunderstorm asthma.

Current recommendations and strategies for preventing thunderstorm asthma include staying indoors during thunderstorms (21, 22). A previous study by Girgis et al. suggested individuals who stayed outdoors or indoors with the windows open had double the risk of developing asthma symptoms than those who stayed indoors with the windows shut (23). This result has been replicated by Lee et al. (17), who reported being indoors with closed windows was rare among those presenting to ED with ETSA in 2016. However, these results are not supported by our study where a similar proportion of individuals who stayed outdoors and indoors developed symptoms during the ETSA event. Although the difference in these results may be explained by a lack of specification in whether windows were left open or shut in our survey, we anticipate that conventional windows may not be able to completely prevent culprit allergen-bearing particles from entering households as their size is typically under 3 microns in diameter (2), and for those at work it is unclear if the climate-control system can filter sub-micron allergenic particles.

Strengths and Limitations

Strengths of this study include a numerically large response size and the timing of the survey to be as close as possible to the ETSA event, thereby minimising problems of recall bias. However, the relative response rate of approximately 6% is poor, leading to an increased risk of selection bias. Other limitations include the inclusion of only healthcare workers, the preponderance of female respondents, and the geographic cluster that the respondents most likely reside in. The respondents all being healthcare-associated workers is significant as they may feel more able to self-manage health issues than the general public. Further, as in all retrospective studies of this kind, those with positive results may be more inclined to participate leading to an over-representation of positive responses. These factors limit the external validity of the work.

Conclusion

ETSA has again risen to prominence due to an epidemic of unprecedented severity in Melbourne, Australia, leading to 10 deaths and thousands of hospital presentations. Our work has shown that there is a potentially large group of individuals who suffered asthma-related symptoms during the ETSA event who did not come to the attention of health professionals. This is important as previous work focusing on emergency department presentations may have underestimated the susceptibility of the general population. Planning for risk-prevention and mitigation strategies on a public health level must take these individuals into account. It is possible that due to factors not quantified or explored in our study these individuals had milder disease, and delineating these may also have important implications for health-promotion and prevention advice.

Author Statements

Competing interests: no relevant disclosures. All authors had full access to the data.

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TABLES AND APPENDICES

Table 1. Comparison of demographic and clinical characteristics of survey participants.

Characteristic	ETSA symptoms (n=132)	No ETSA symptoms (n=383)	<i>p</i>
Females, <i>n</i> (%)	97 (76.4)	314 (84.2)	0.047
Age (years)			0.023
18–25, <i>n</i> (%)	10 (7.6)	13 (3.4)	-
26–34, <i>n</i> (%)	22 (16.7)	78 (20.4)	-
35–44, <i>n</i> (%)	33 (25.0)	65 (17.0)	-
45–54, <i>n</i> (%)	38 (28.8)	108 (28.2)	-
55–64, <i>n</i> (%)	20 (15.2)	99 (25.8)	-
≥ 65, <i>n</i> (%)	3 (2.3)	12 (3.1)	-
Concurrent allergic rhinitis symptoms, <i>n</i> (%)	76 (57.6)	78 (20.4)	<0.001
Outdoor location, <i>n</i> (%)	16 (12.2)	46 (12.0)	1.00
History of previous asthma, <i>n</i> (%)	58 (43.9)	108 (28.2)	0.001
History of allergic rhinitis, <i>n</i> (%)	97 (73.5)	165 (43.1)	<0.001
History of atopic dermatitis, <i>n</i> (%)	15 (11.4)	56 (14.6)	0.38
History of food allergy, <i>n</i> (%)	18 (13.6)	32 (8.4)	0.077
History of cat allergy, <i>n</i> (%)	16 (12.1)	39 (10.2)	0.52
History of dust mite allergy, <i>n</i> (%)	29 (22.0)	40 (10.4)	0.001
History of grass allergy, <i>n</i> (%)	53 (40.2)	60 (15.7)	<0.001
History of tree allergy, <i>n</i> (%)	18 (13.6)	19 (5.0)	0.001
History of mould allergy, <i>n</i> (%)	9 (6.8)	15 (3.9)	0.23
History of weed allergy, <i>n</i> (%)	16 (12.1)	13 (3.4)	<0.001
Ethnicity			
Caucasian, <i>n</i> (%)	89 (67.4)	329 (85.9)	-
East Asian, <i>n</i> (%)	17 (12.9)	21 (5.5)	0.002
South Asian, <i>n</i> (%)	15 (11.4)	13 (3.4)	<0.001
African, <i>n</i> (%)	1 (0.8)	1 (0.3)	0.38
Hispanic, <i>n</i> (%)	1 (0.8)	1 (0.3)	0.38
Arab, <i>n</i> (%)	1 (0.8)	1 (0.3)	0.38

Indigenous Australian, <i>n</i> (%)	2 (1.5)	1 (0.3)	0.12
Total, <i>n</i> (%)	132 (25.6)	383 (74.4)	

Table 2. Odds ratios and adjusted odds ratios of experiencing ETSA-like symptoms from univariable and multivariable logistic regression analysis.

Predictor	Univariable analysis			Multivariable analysis		
	OR	95% CI	<i>p</i>	Adjusted OR	95% CI	<i>p</i>
Asian ethnicity	3.28	1.93, 5.59	<0.001	3.24	1.74, 6.05	<0.001
History of allergic rhinitis	3.66	2.37, 5.66	<0.001	2.77	1.65, 4.65	<0.001
History of grass allergy	3.61	2.32, 5.63	<0.001	2.05	1.12, 3.74	0.019
History of asthma	2.00	1.33, 3.01	0.001	1.67	1.03, 2.71	0.037
History of food allergy	1.73	0.94, 3.20	0.080	1.43	0.71, 2.88	0.32
Age < 45 years	1.41	0.95, 2.10	0.089	1.26	0.79, 2.01	0.33
History of weed allergy	3.93	1.83, 8.40	<0.001	1.17	0.41, 3.30	0.77
History of tree allergy	3.02	1.54, 5.96	0.001	1.12	0.45, 2.83	0.81
Male	1.65	1.00, 2.70	0.048	1.11	0.62, 1.98	0.72
History of dust mite allergy	2.41	1.43, 4.09	0.001	0.89	0.44, 1.78	0.74

Appendix 1 – Survey Questions

(1) On the afternoon / evening of 21/11, the day of the thunderstorm asthma, did you have any of the following symptoms? (Please tick all that apply)

- a. Wheeze
- b. Cough
- c. Shortness of breath
- d. Chest tightness
- e. Hay fever (e.g., sneezing, runny nose, itchy eyes or nose, blocked nose)
- f. None
- g. Other (please specify)

(2) [Of those who ticked at least one symptom other than 'None' in Q1]

What action did you take? (please tick all that apply)

- a. Took own treatment
- b. Saw the local doctor
- c. Went to hospital and was admitted
- d. Went to hospital but was not admitted
- e. Nothing

(3) [Of those who took their own treatment]

What treatment did you take? (please tick all that apply)

- a. Puffers (e.g., Ventolin)
- b. Antihistamines
- c. EpiPen
- d. Oral steroids
- e. Other (please specify)

(4) Where were you predominantly on Monday 21/11 afternoon / evening?

- a. Indoors
- b. Outdoors

(5) Have you EVER been diagnosed with any of the following? (Please tick all that apply)

- a. Asthma
- b. Hayfever

- c. Eczema
- d. COPD / emphysema
- e. Food allergy
- f. None of the above

(6) [Of those with a previous diagnosis of asthma]

How would you BEST describe your diagnosis of asthma?

- a. Childhood / teenage asthma only, but NOT current (within the last 12 months)
- b. Current asthma (within the last 12 months) but only intermittent with colds / hayfever / exercise / triggers
- c. Current asthma (within the last 12 months) WITHOUT triggers, but only on relievers
- d. Current asthma (within the last 12 months) and using preventers

(7) [For those without a previous diagnosis of asthma]

Have you EVER had these symptoms with colds / hayfever / exercise / smells OR have they woken you from sleep? (Please tick all that apply)

- a. Cough
- b. Wheeze
- c. Chest tightness
- d. Shortness of breath
- e. None of the above

(8) Do you have a diagnosed history of allergy to any of the following? (please tick all that apply)

- a. Grass pollens
- b. Tree pollens
- c. Weed pollens
- d. Moulds
- e. House dust mite
- f. Cat
- g. None of the above
- h. Other (please specify)

(9) How old are you?

- a. 18-25

- b. 26-34
- c. 35-44
- d. 45-54
- e. 55-64
- f. 65-74
- g. 75 or older
- h. Prefer not to say

(10) What sex are you?

- a. Female
- b. Male
- c. Prefer not to say

(11) How do you identify ethnically?

- a. Indigenous Australia and / or Torres Strait Islander
- b. Caucasian / White
- c. Asian (NOT Indian or subcontinental)
- d. Indian / Subcontinental
- e. Pacific islander
- f. Black (African / African American)
- g. Hispanic or Latino
- h. More than one of the above
- i. Prefer not to say
- j. Other (please specify)

(12) If you would like to make any other comments that you think could be helpful in furthering our understanding of thunderstorm asthma, please do so below

- a. [Comment Box]